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# NOVEL KINETIC IMPACT TECHNIQUE FOR DEFLECTION OF RUBBLE PILE, NEAR EARTH ASTEROIDS

**Abstract**

This paper describes a novel kinetic impactor approach that promises accurate velocity change for the deflection of hazardous Near Earth Asteroids (NEAs). Among various mitigation technologies, the kinetic impact deflection strategy has the simplest concept – linear momentum is modified by driving a mass onto it. Thus, the study of the kinetic impact collision avoidance strategy has a practical importance. A "rubble pile" asteroid is defined as a weak aggregate of large and small components held together by gravity rather than material strength. Asteroid 25143 Itokawa is the first unambiguously identified rubble pile, as observed by Hayabusa. Asteroid Apophis has an LL-chondritic composition, and most probably, it also has a rubble pile structure. To compute the dynamical motion of such complex bodies, one of the authors previously developed an efficient rubble pile dynamics simulation, which has the following features: (1) for the intervals of continuous motion, the integration routine can employ relatively large time steps, and (2) when contacts occur among the constituent "boulders of the rubble pile, the system degrees of freedom are reduced. These features speed integration by several orders of magnitude and allow for simulation of large systems. Earlier work used this formulation to simulate Asteroid Apophis 99942 as a rubble pile, hit in 2029 by an impactor vehicle carrying sufficient momentum to alter the asteroid's position by 3 Earth radii 7 years later. We found that the velocity change of the asteroid is highly sensitive to the impact location, and unless there is very detailed knowledge of the internal structure, there is a high probability of serious error in the resulting velocity change. Indeed, in most cases either little or no momentum is effectively transferred or the velocity change is in the wrong direction. In this paper, we describe the design of an impactor vehicle capable of controlled fragmentation before impact so that the asteroid receives momentum from numerous components spread over its surface. The simulation studies shown here indicate that the desired velocity change can be achieved with excellent accuracy without detailed knowledge of the internal structure.